PATIENT HEALTH MONITORING SYSTEM

Minor Project Report

Submitted for the partial fulfillment of the degree of

Bachelor of Technology

In

Internet of Things (IOT)

Submitted By

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UNDER THE SUPERVISION AND GUIDANCE OF

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June 2024

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ABSTRACT

The Patient Health Monitoring System is a compact, low-cost, and efficient device designed to measure and monitor essential health parameters such as heart rate, oxygen saturation (SpO2), and body temperature. This project uses an Arduino Uno microcontroller, paired with sensors like the MAX30100 Pulse Oximeter and LM35 Temperature Sensor, to collect real-time data. The results are displayed on a 16x2 LCD and provide visual alerts via LEDs when parameters exceed normal thresholds, ensuring immediate attention to critical situations. The system is designed for accessibility and ease of use, catering to remote areas and home care environments where professional medical equipment may not be readily available. By eliminating the need for complex IoT setups, this project emphasizes simplicity while maintaining accuracy and reliability. The proposed system bridges the gap between expensive clinical devices and affordable personal healthcare monitoring solutions, making it ideal for proactive health management. This project demonstrates the potential for affordable healthcare technology to improve individual well-being, reduce the burden on healthcare facilities, and pave the way for future advancements in portable medical devices.

ACKNOWLEDGEMENT

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CONTENT

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ACRONYMS

1. **MCU**: Microcontroller Unit
2. **PWM**: Pulse Width Modulation
3. **IDE**: Integrated Development Environment
4. **GND**: Ground
5. **VCC**: Voltage Common Collector (or Voltage at the Common Collector, indicating the power supply for circuits)
6. **I2C:** Inter-Integrated Circuit
7. **LCD:** Liquid Crystal Display
8. **SpO2:** Oxygen Saturation Level
9. **BPM:** Beats Per Minute
10. **HC-05:** Bluetooth Module
11. **MAX30100:** Pulse Oximeter Sensor
12. **VCC:** Voltage Common Collector
13. **GND:** Ground
14. **IoT:** Internet of Things
15. **UNO:** Universal Network Object (Arduino Uno)

NOMENCLATURE

1. Arduino Uno (MCU): It is responsible for controlling signals from the sensors and motor drivers apart from processing.
2. PWM: (Pulse Width Modulation), A method by which the speed of a motor is regulated by changing the duration of the pulse signal in contact with the motor.
3. VCC: (Voltage Common Collector), The pin used for providing power to a component to which usually a positive voltage is connected.
4. HR: (Heart Rate), measured in beats per minute (BPM).
5. BPM: (Beats Per Minute), the unit of heart rate measurement.
6. SpO2: (Peripheral Capillary Oxygen Saturation), the percentage of oxygenated hemoglobin in the blood.
7. T: (Body temperature), measured in degrees Celsius (°C).
8. MAX30100: Pulse Oximeter and Heart Rate Sensor used for SpO2 and HR measurement.
9. LM35: Temperature sensor used to measure body temperature.
10. LCD: 16x2 Liquid Crystal Display for displaying real-time health data.
11. LED: (Light-Emitting Diodes) used as indicators for alerts (e.g., abnormal SpO2 or HR).
12. VCC: (Voltage Common Collector), the power supply pin for components.
13. I2C: (Inter-Integrated Circuit), communication protocol between devices like LCD and sensors.
14. PWM: (Pulse Width Modulation), used to control LED brightness or other outputs.
15. Threshold Predefined limits for HR, SpO2, and temperature to trigger alerts.
16. Alert LED: LED indicator that lights up when values deviate from the normal range.
17. GND: (Ground): The phase from which voltage is measured and the electrical current return path.

List of Figures

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Chapter 1: Introduction

The Patient Health Monitoring System is a cost-effective and user-friendly solution designed to track essential health parameters such as heart rate, oxygen saturation (SpO2), and body temperature. Monitoring these vital signs is crucial in healthcare, as they provide insights into an individual's physiological state and can help in the early detection of critical health conditions.

This system is particularly valuable in the context of increasing global demand for portable and affordable healthcare solutions. It leverages an Arduino Uno microcontroller, along with sensors such as the MAX30100 Pulse Oximeter and LM35 Temperature Sensor, to collect real-time data. The data is displayed on a 16x2 Liquid Crystal Display (LCD), offering a clear and straightforward interface for users. Visual alerts through LEDs are incorporated to ensure that deviations from normal health parameters are immediately highlighted.

The project is designed for applications in home-based healthcare, remote monitoring, and resource-constrained environments. By eliminating the dependency on expensive and complex medical devices, the system bridges the gap between advanced clinical monitoring tools and accessible personal health monitoring solutions.

This introduction to the Patient Health Monitoring System highlights the project's relevance in addressing current healthcare challenges while providing a platform for further development in personalized medical technology.

CHAPTER 2: LITERATURE SURVEY

For The development of patient health monitoring systems has been a key area of research due to their potential to improve healthcare accessibility, reduce the burden on healthcare professionals, and provide timely interventions. These systems typically involve the collection and analysis of various vital parameters such as heart rate, oxygen saturation (SpO2), and body temperature, which are critical in diagnosing and managing chronic diseases and emergency situations. This literature survey explores existing works in the field of health monitoring systems, their components, and their impact on healthcare.

2.1. Wearable Health Monitoring Systems

Wearable health monitoring systems have become increasingly popular due to their ability to track vital health parameters continuously and non-invasively. Several studies have explored the integration of sensors with portable devices for real-time health monitoring. For example, the work of Zhang et al. (2017) discusses the development of wearable devices capable of measuring heart rate, SpO2, and body temperature, with the use of a Pulse Oximeter and temperature sensors. These devices can transmit data to mobile phones or cloud platforms, making it easier for users and healthcare providers to monitor health remotely.

2.2. Use of Arduino in Health Monitoring

The **Arduino platform** has been widely used in health monitoring systems due to its low cost, ease of programming, and flexibility. According to Gupta et al. (2018), Arduino-based health monitoring systems can collect data from sensors, display information on LCDs, and provide alerts using LEDs or buzzers. The integration of the MAX30100 pulse oximeter sensor with Arduino for measuring SpO2 and heart rate has been explored in multiple studies, such as Sharma et al. (2019). Their system used Arduino to collect data from the MAX30100 sensor and display the information on an LCD screen. Additionally, alerts were generated when heart rate or SpO2 levels deviated from predefined thresholds.

2.3. Applications of Pulse Oximetry in Remote Monitoring

Pulse oximetry is a non-invasive method for monitoring the oxygen saturation of the blood. MAX30100, a widely used pulse oximeter sensor, is designed to measure both SpO2 and heart rate simultaneously using infrared and red light. Thakur et al. (2020) investigated the role of pulse oximeters in early detection of respiratory diseases and discussed the growing importance of SpO2 monitoring in managing conditions like COVID-19. Their research highlights the increasing need for portable and affordable SpO2 monitors, especially for home care and remote healthcare services.

2.4. Temperature Measurement and Monitoring

Monitoring body temperature is another essential parameter for detecting infections or fever. LM35 temperature sensors are commonly used in many health monitoring systems due to their accuracy and ease of use. Patel et al. (2018) demonstrated the integration of LM35 with an Arduino to monitor body temperature in real-time, providing valuable data for early diagnosis of fevers or infections. Similar studies have explored the use of LM35 for real-time health temperature monitoring, which is crucial for detecting conditions like hypothermia or fever.

2.5. Health Monitoring System with IoT Integration

While this project does not involve IoT modules like Wi-Fi or Bluetooth, several studies have incorporated the Internet of Things (IoT) into health monitoring systems. Saha et al. (2021) explored how IoT can enhance healthcare by enabling remote monitoring of patients' vital signs. In their system, patients' health data (including heart rate, SpO2, and temperature) was transmitted over Wi-Fi or Bluetooth to a cloud platform for further analysis. This approach improves patient care by enabling healthcare professionals to access real-time data remotely and intervene if necessary.

2.6. Real-Time Monitoring and Alerts

Real-time health monitoring systems are designed to detect abnormal conditions and generate timely alerts. Chaudhary et al. (2020) emphasized the importance of early warning systems in preventing health crises. In their research, they developed an Arduino-based health monitoring system that provided real-time data and visual alerts for abnormal SpO2, heart rate, and temperature. These alerts were delivered via LEDs and buzzers, which are similar to the approach used in this project.

2.7. Challenges and Future Trends

The main challenges in developing health monitoring systems include power consumption, sensor accuracy, and user comfort. However, advancements in sensor technology and microcontroller efficiency have significantly improved the functionality of portable health monitoring devices. Future trends in health monitoring systems include the integration of machine learning algorithms for predictive health analytics, wearable patches for continuous monitoring, and advancements in AI-based diagnostics.

CHAPTER 3: COMPONENTS USED

Table of Components Used in this Project:

Component Name	Quantity
Arduino Uno	1
MAX30100 Pulse Oximeter	1
LM35 Temperature Sensor	1
16x2 LCD Display	1
LED	1
9V Battery	1
Breadboard	1
Jumper Wires	15
Resistors	2

Table 1. Components Required

3.1. Arduino Uno

The Arduino Uno is a microcontroller board based on the ATmega328P, designed for easy programming and prototyping. It has 14 digital I/O pins (6 for PWM) and 6 analog inputs, enabling the control of motors and sensors. The board is programmable through the Arduino IDE using a USB cable and operates on 5V logic. Its simplicity, affordability, and open-source nature make it ideal for small-scale robotics projects like obstacle avoidance robots. Itprocesses sensor data from the HC-SR04 and provides instructions to the motor driver board, enabling real-time decision-making.

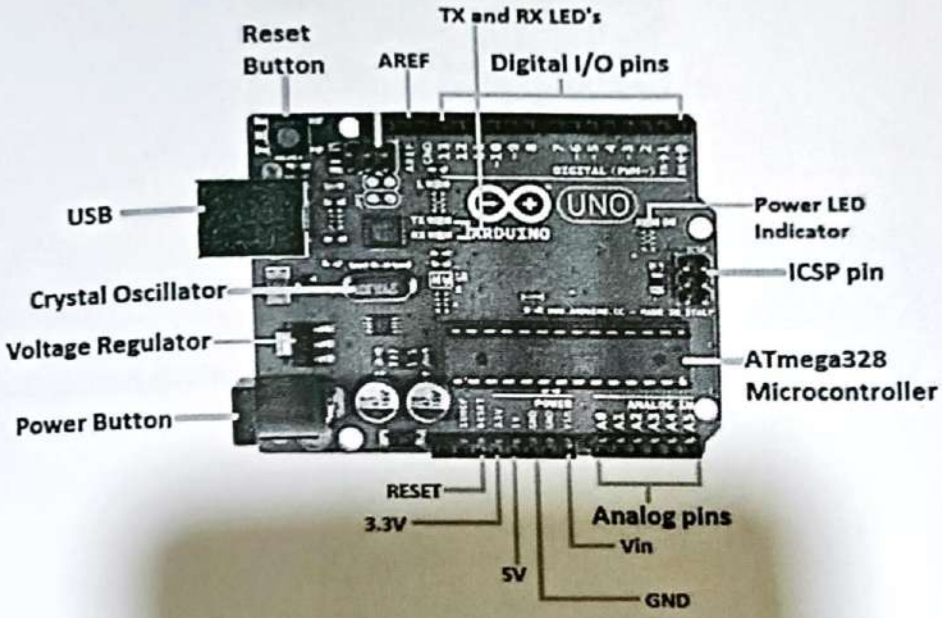

Figure 1. Arduino Uno

2. MAX30100 Pulse Oximeter

The MAX30100 is an integrated sensor that measures heart rate (BPM) and blood oxygen saturation (SpO2) by emitting light through the skin and detecting the reflection. It measures oxygen levels (SpO2) and heart rate by using infrared and red LEDs, then sends the data to the Arduino for display.

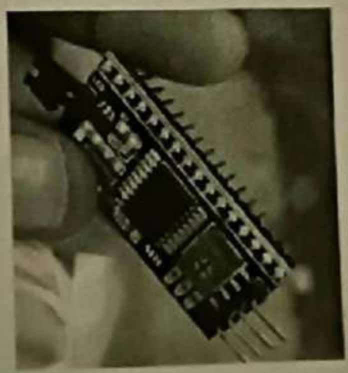

Figure 2. MAX30100 Sensor

3. LM35 Temperature Sensor

The LM35 is a temperature sensor that provides Analog output, directly proportional to the temperature in Celsius. Measures body temperature and provides real-time temperature readings to the Arduino.

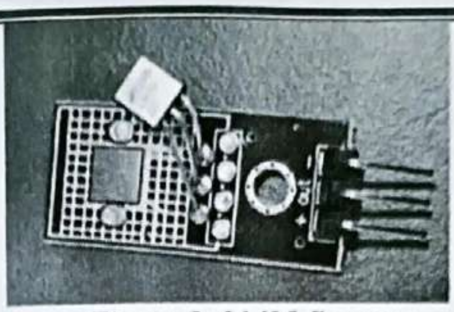

Figure 3. LM35 Sensor

4. **16x2 LCD Display**

The LCD (Liquid Crystal Display) is a 16x2 screen that can display up to 32 characters of text. Displays the real-time data from the sensors, including heart rate, SpO2, and body temperature.

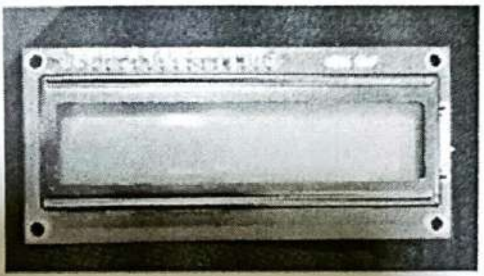

Figure 4. LCD Display Module

5. **LED**

Light Emitting Diodes (LEDs) are used for visual alerts and indicators. Displays visual feedback for different health conditions. For example, a green LED can indicate normal SpO2 levels, a yellow LED for warning levels, and a red LED for critical levels.

7. **Jumper Wires**

Jumper wires are used to connect various components (sensors, Arduino, LCD, etc.) on the breadboard or Arduino board. Facilitates electrical connections between the components.

8. **Breadboard**

A breadboard is a tool used for prototyping and connecting electronic components without soldering. Used for connecting and testing the components before finalizing the circuit.

Figure 5. Breadboard

Power Supply (USB Cable or Battery)

The power supply provides the necessary voltage to run the Arduino and other connected components. Powers the entire system by connecting the Arduino to a USB port or an external battery source.

Resistors

Resistors are passive components used to limit current and protect circuits from excessive current flow. Used in various parts of the circuit to limit current, particularly with LEDs and sensors.

. 9V Battery

A 9V battery powers the Arduino Uno and motor driver, ensuring uninterrupted operation of the robot. It provides a convenient and portable power source, with sufficient voltage to support the sensors, motors, and microcontroller. A battery connector simplifies integration, while its compact size allows for easy placement within the robot chassis.

Figure 6. Battery

CHAPTER 4: HARDWARE ASSEMBLY AND CONSTRUCTION

4.1 Assembly of Components for Health Monitoring System:

This chapter outlines the process of assembling the hardware components for the Patient Health Monitoring System. The construction of the system involves connecting various sensors, the Arduino Uno, the LCD display, and other components to ensure proper data collection, processing, and display. Below are the detailed steps involved in the hardware assembly.

4.2. Step-by-Step Hardware Assembly

4.2.1. Connecting the MAX30100 Pulse Oximeter to Arduino Uno

The MAX30100 Pulse Oximeter is a sensor used to measure heart rate and oxygen saturation. It communicates with the Arduino Uno via the I2C protocol (SDA, SCL).

1. VCC (MAX30100) → 5V (Arduino Uno)
2. GND (MAX30100) → GND (Arduino Uno)
3. SDA (MAX30100) → A4 (Arduino Uno)
4. SCL (MAX30100) → A5 (Arduino Uno)

4.2.2. Connecting the LM35 Temperature Sensor to Arduino Uno

The **LM35** sensor is used to measure body temperature and provides an analog output.

1. VCC (LM35) → 5V (Arduino Uno)
2. GND (LM35) → GND (Arduino Uno)
3. OUT (LM35) → A0 (Arduino Uno)

4.2.3. Connecting the 16x2 LCD Display to Arduino Uno

The **16x2 LCD Display** with an I2C interface is used to display the real-time health data.

1. VCC (LCD) → 5V (Arduino Uno)
2. GND (LCD) → GND (Arduino Uno)
3. SDA (LCD) → A4 (Arduino Uno)
4. SCL (LCD) → A5 (Arduino Uno)

4.2.4. Connecting LEDs to Arduino Uno

LEDs will be used for visual alerts, with each color representing a different health state.

1. **Green LED** (Normal SpO2) → Pin 8 (Arduino Uno) (with a current-limiting resistor, usually 220Ω)

Final Assembly and Enclosure

Once the system is tested and working, the components can be housed in a suitable enclosure or casing for portability and protection. A 3D printed chassis can be used to house the components neatly, ensuring that the sensors are exposed for accurate readings, while also protecting the electronics.

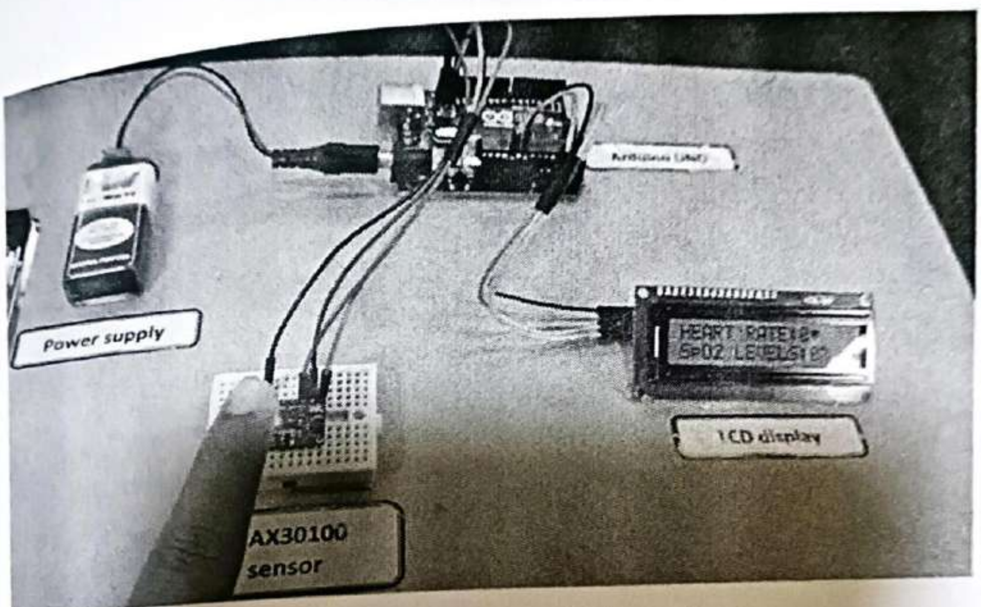

Figure 6. Circuit Diagram and Connections

CHAPTER 5: WORKING OF MODEL

Obstacle Avoidance in the Obstacle Avoiding RobotThe Patient Health Monitoring System is designed to continuously monitor and display key health parameters such as heart rate, blood oxygen saturation (SpO2), and body temperature. The system uses various sensors, an Arduino Uno microcontroller, and an LCD display to collect, process, and display the health data in real-time. Below is a detailed explanation of how the system works:

1. System Overview

The system consists of the following main components:

- **Arduino Uno**: The central control unit that processes data from sensors.
- **MAX30100 Pulse Oximeter**: Measures heart rate and SpO2 levels.
- **LM35 Temperature Sensor**: Measures the body temperature.
- **16x2 LCD Display**: Displays the measured health parameters.
- **LEDs (Green, Yellow, Red)**: Indicate the health status based on SpO2 levels.
- **Buzzer**: Provides an audible alert when any health parameter goes beyond a predefined threshold.

Each component plays a specific role in acquiring, processing, and displaying the data. Below is a detailed breakdown of the working flow:

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2. Step-by-Step Working Process

2.1. Powering the System

- When the system is powered ON, the Arduino Uno receives power either from a 9V battery or through a USB cable.
- The microcontroller is responsible for controlling all connected devices (sensors, LEDs, buzzer) based on the sensor data.

2.2. Heart Rate and SpO2 Measurement (MAX30100)

- The MAX30100 Pulse Oximeter uses infrared and red light to measure the heart rate and SpO2 levels.
  - **Infrared Light (IR)**: Passes through the skin and reflects back to the sensor. The amount of light absorbed by the blood vessels changes as the heart pumps blood, which allows the calculation of heart rate.
  - **Red Light**: The amount of red light absorbed is compared to the infrared light to calculate the **oxygen saturation** level in the blood (SpO2).
  - The MAX30100 sensor sends this data to the Arduino Uno via the I2C protocol (through the SDA and SCL pins).
  - The Arduino processes this data and calculates the BPM (beats per minute) and SpO2 percentage.

2.3. Body Temperature Measurement (LM35)

2. **Data Collection**:
   - The Arduino reads heart rate and SpO2 data from the MAX30100 Pulse Oximeter using I2C communication.
   - The temperature is read from the LM35 using the analog input pin.
3. **Data Processing**:
   - The heart rate and SpO2 are processed and displayed on the LCD.
   - The temperature value is converted from voltage to Celsius and displayed on the LCD.
4. **Health Monitoring**:
   - The system constantly checks the SpO2 and temperature against predefined thresholds to determine the health status.
   - The LEDs are turned on/off based on the SpO2 levels.
   - The buzzer is triggered if the health metrics exceed the critical thresholds.
5. **Display Update**:
   - The LCD displays real-time readings of the heart rate, SpO2, and body temperature.

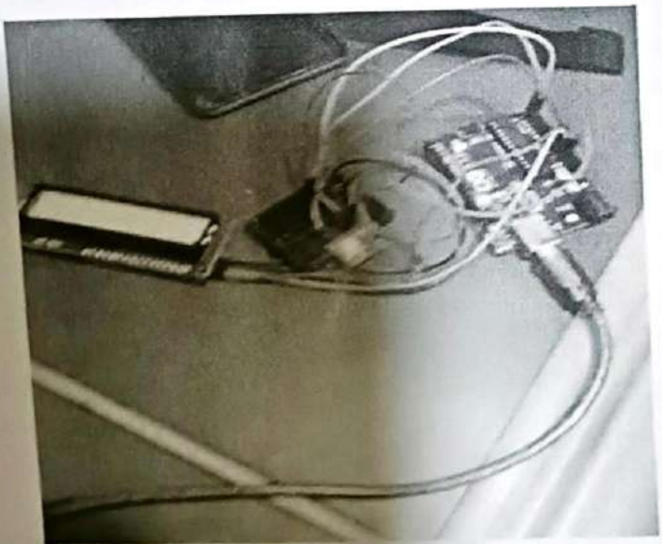

Figure 7. Final Setup of the Model (integration of all sensors along with code)

CHAPTER 5: Flow Diagram

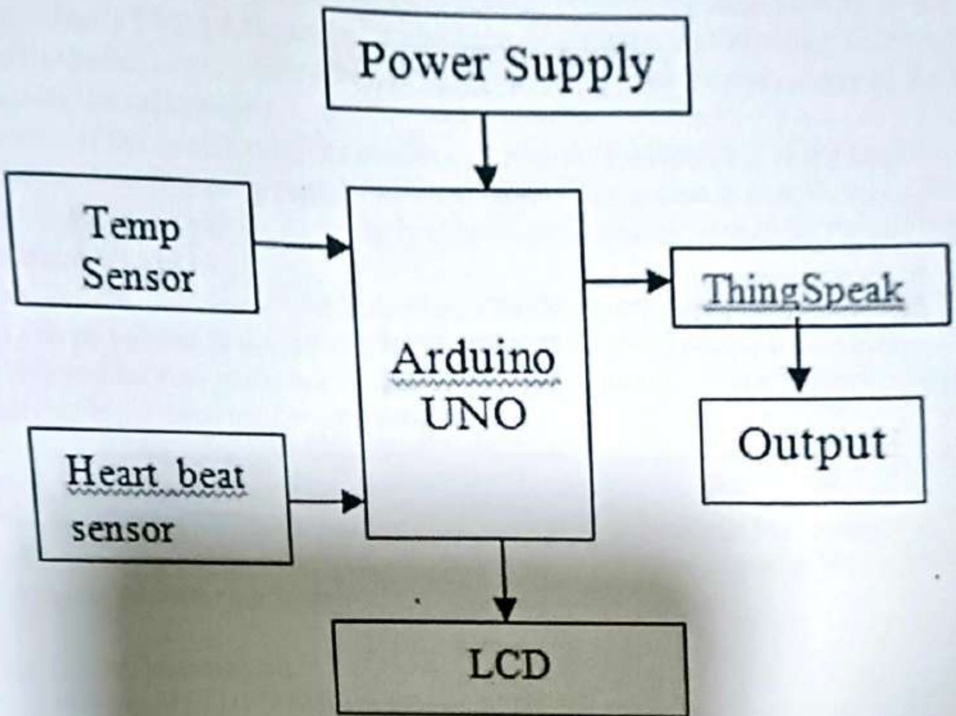

Fig. 6 Block diagram of health monitoring system

re Scope

the current system provides basic functionality, several improvements and additions can be made nce its effectiveness and broaden its application. Below are some potential future enhancements e Patient Health Monitoring System:

1. **Wireless Data Transmission:**
   - Integrating **Wi-Fi (ESP8266)** or **Bluetooth (HC-05)** modules could allow the system to transmit data to a mobile or web application, enabling remote monitoring of patients' health status.
   - This could be particularly useful for telemedicine applications or home healthcare systems where healthcare providers can monitor patient vitals remotely.
2. **Integration with Mobile or Web App:**
   - The system could be connected to a mobile app or a web interface where the data can be displayed in graphical form, stored, and analyzed. This will allow patients to track their health trends over time.
   - Mobile apps could also send notifications in case of abnormal readings, improving the response time in case of emergencies.
3. **Adding More Health Parameters:**
   - The system can be extended to include more sensors such as **ECG (Electrocardiogram)** for heart activity, **blood pressure sensors**, and **glucose sensors** for a more comprehensive health monitoring system.
   - This would turn the system into a **multi-parameter patient monitoring system**, capable of providing more detailed insights into a patient's health.
4. **Artificial Intelligence (AI) Integration:**
   - AI algorithms could be introduced to detect trends or patterns in the data and predict health conditions, such as detecting early signs of a **heart attack, respiratory failure**, or **fever**.
   - Machine learning models could analyze historical data to improve prediction accuracy and provide early warnings for potential health issues.
5. **Real-Time Alerts to Doctors/Family Members:**
   - The system could be extended to automatically alert healthcare providers, family members, or caregivers if the patient's vitals go out of range. These alerts could be sent via SMS, email, or mobile notifications.
   - This would ensure timely interven ... ny medical emergency.

6. **Battery Optimization**:
   - For better portability, the system could be optimized to run on **low-power devices** and include **long-lasting batteries**. This is important for wearable devices or applications that require continuous monitoring over extended periods.
7. **Cloud-Based Data Storage**:
   - Data from the sensors could be uploaded to the cloud for long-term storage and analysis. This would allow the system to be used as part of a larger **health management system**, where doctors can analyze trends and make decisions based on long-term health data.
8. **Integration with Wearable Devices**:
   - The system could be integrated with **wearable health devices** such as smartwatches or fitness trackers to gather more health metrics and provide seamless monitoring for users.

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